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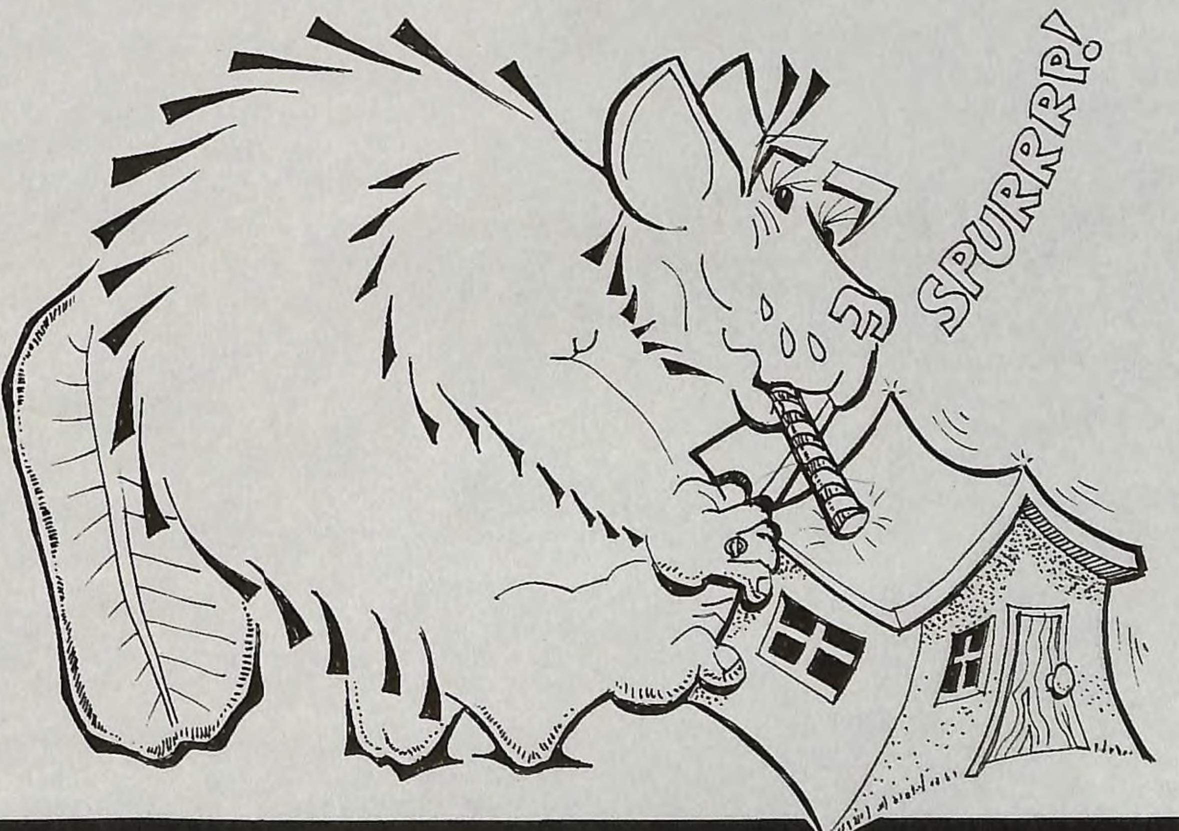

From the Editor . . .

We know that there is lots of room for improvement of construction practices and details. We can always improve our work. Recently I was chatting with a couple of builders, discussing alternative details that would improve wood frame construction and allow for more effective insulation installation. The some of the details discussed might add an extra task to one trade, but the offsetting savings would be gained in the work done by other trades, as they would have less to do. The overall benefits would be a better-built and better-insulated house.

The builders pointed out all the reasons why it is difficult to make changes. Being very pragmatic, they pointed out why so often they just follow along, and do the best they can in a tough situation.

Unfortunately, our industry has evolved a management structure that makes it difficult to implement changes. We see extreme specialization on the job site today, with each task done by highly specialized individuals in a narrow field who may not fully appreciate the significance of some of their tasks. This has its good and bad points. On the positive side, the specialized tasks are done well by individuals who may not have had in-depth building training. On the down side, they may not be able to recognize troubles in anything other than their own work, even though the consequences may be big on the work of other trades.

This specialization has been spurred on by the compensation approaches followed today where so much of the work is done mostly on a piecework basis. As a result, anyone trying to make changes in construction details has to fight subtrades that are locked into a set way of doing things and not at all keen to consider changes, because change means time to review procedures and a learning curve. Piecework doesn't always encourage that.

Sometimes proposed changes may provide a better, more durable solutions to a construction detail and may result in simpler, time saving construction. However, the piecework approach does not encourage that because the time saving may apply to someone else, so that while overall savings and improvements are to be gained, the trade offs involved are not recognized by everyone.

I think that we've been overwhelmed by a new theology of business management developed by management consultants. The priesthood for this new theology is the army of MBAs that are supported by lawyers. The dogma is efficiency and productivity, at the lowest cost with the least liability.

Unfortunately, very few of this new priesthood have any understanding of the technical issues involved. As a result, many decisions are made by the MBAs on the basis of the bottom line and liability risk aversion, rather than on the basis of correct technical analysis for the whole project.

Even the frequently heard mantra of "thinking outside the box" doesn't provide enough leeway or give appropriate consideration to technical considerations.Consequently, we have a system that is very difficult to change.

Richard Kadulski,
Editor

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Air Tightness Testing

Air tightness of a building affects building performance. Air leakage is a major cause of moisture problems in buildings because it is the movement of warm moist air outward that carries moisture from inside to outside. The warm moist indoor air will deposit its moisture as it encounters cooler surfaces, thus creating conditions for the growth of mould and other biological induced deterioration. In cold climates air leakage can also lead to the formation of ice in and on the exterior building envelope components.

Moist air leaking out through the building envelope is not only an important aspect of building durability, but it also has a big impact on energy use and comfort. From an energy standpoint alone it is always desirable to increase air tightness. However, if it assumed that uncontrolled air infiltration will provide the needed air change to dilute indoor contaminants, as is the case in many older houses, then indoor air quality will suffer as infiltration air may be drawn in from contaminated areas such as attics, crawlspaces or even the outdoors. Sometimes the building envelope components themselves may be a source of contamination because of mould or toxic materials. Indoor air quality can suffer even though total air change rates may be high.

The most noticeable impact of poor air tightness is drafts and noise. Air-tight buildings provide increased comfort levels to the occupants as well as reduced energy use.

Since we started insulating buildings for comfort and energy savings, moisture movement by air leakage has become significant because we have changed the thermal profile of the construction assembly. The temperature difference across the wall can be large - the exterior elements are now much colder and colder surfaces do not dry quickly, so structural deterioration can happen quickly.

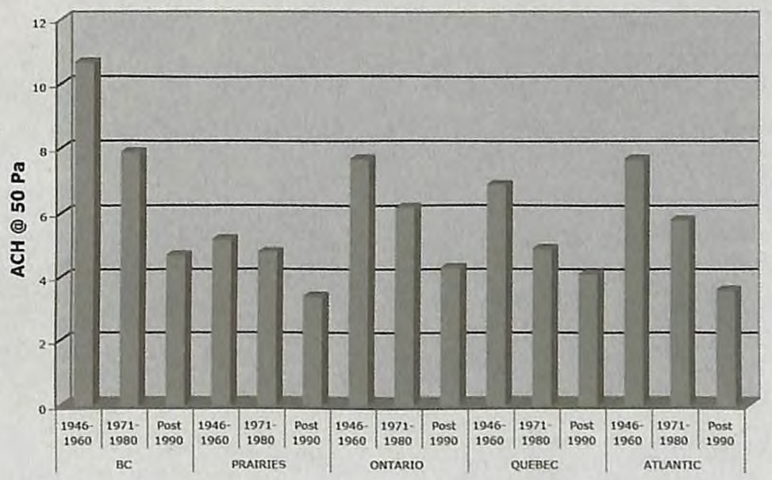
Factors that affect air tightness include age of construction, building type (single-family versus multi-family dwellings), severe climate and construction materials. Today's construction materials and practices are providing ever tighter buildings. Envelope air leakage and/or infiltration can have a significant impact on energy consumption and on the indoor air quality of all buildings regardless of age, size or construction.

It is also important to understand the air tightness level of a house in order to avoid other problems. Combustion equipment safety and makeup air for exhaust fans and combustion appliances must be dealt with separately. In the past it was less of a concern simply because buildings were so drafty it was difficult to create excessive negative pressures to be a concern even if there was not enough dedicated combustion air supply.

Dwellings in severe climate areas such as Sweden, Norway and Canada are known to be more air tight than those that are located in milder climate areas of the US and the UK. Within Canada it has been noted that the air tightness of houses has been increasing over the years largely due to changing building practices. However, within Canada there is a regional variation in the air tightness. Houses built today on the prairies are extremely airtight, while those in Coastal B.C. are the leakiest.

An important reason for tighter construction is to conserve energy use and maintain thermal comfort. However, it is valuable to understand just how much air leakage there is in a building

Typical Airtightness by Region and Date of Construction



and where leakage paths are located. We now have an easy to use diagnostic tool that can be used for both new and old construction.

The blower door was designed to measure a building's air tightness. The blower door as we know it was developed in Sweden in the 1970s as a window-mounted fan that became a door in North America. They were first developed as a research tool but it quickly became evident that they offered a useful diagnostic tool. Early models were cumbersome pieces of equipment. Today's equipment has been refined into a manageable package that a single person can easily handle and pack into the trunk of a compact car.

The fan is a variable speed blower that is temporarily installed in an exterior doorframe. The blower door pressure test uses a fan to pressurize or de-pressurize a building in order to measure the resultant airflow pressure. The fan measurements are then input into computer software along with house dimensions and atmospheric conditions to calculate an estimated infiltration rate. The numbers tell us how airtight (or how loose) a building is.

A blower door test is a crucial part of the quality assurance protocol used in programs such as R-2000 and Energuide for Houses ratings. The test protocol used is the CGBS (Canadian General Standards Board) 149.10 standard. The basic technique involves measuring the airflow through the fan necessary to maintain a steady pressure across the building envelope.

Blower door testing, however, does not identify what shape or where the holes are. The blower door test simply calculates the total area of all air leakage paths which are referred to as the equivalent leakage area. The equivalent leakage area roughly corresponds to the combined area of all the house's leaks. When the building is depressurised, a walk through inspection with a smoke pencil should help locate major air leakage paths.

Field measurements gained from blower door tests are responsible for our current knowledge about the air tightness of buildings. As blower door usage increased, researchers discovered that hidden leaks accounted for a much larger proportion of air leakage in a home than the more obvious locations such as windows, doors and electrical outlets.

The effect of air leakage through a hole in the building envelope will vary with the shape of the hole. A long thin crack, for example, responds less to variations in air pressure than a round hole does.

Blower door testing is beginning to be used in larger commercial and institutional buildings. Testing is being done for energy diagnostics and also for fire suppression system testing. Recent research has shown that North American commercial and institutional buildings are not as airtight as was assumed. New regulations being implemented in the UK will require that all new buildings with a gross floor area of more than 100 m^2 must be tested for air leakage to comply with the energy codes.

Equivalent leakage area is the calculated area of a theoretical sharp-edged hole in the building envelope that would leak as much as all of the building's actual holes at a pressure difference of 10 Pa.

In order to compare one building to another, regardless of size, is desirable to have a standard measure that is related to the size of building.

Normalized Leakage Area (NLA) is the leakage area as a proportion of the total exterior surface area of a building. It allows easy comparison between different sizes of houses. The R-2000 Standard sets a maximum allowable of 0.7 cm^2/m^2 of exterior surface area (1 $in^2/100ft^2$).

Air Changes per Hour (ACH). Building volume is sometimes used to compare air flows. When building volume is used to compare data the result is normally expressed in air changes per hour at a reference pressure. Air changes per hour at 50 Pascals is probably the most common air tightness measure used.

What Do The Air Test Numbers Mean?

Translating blower door measurements into an average air change rate is not easy. The rate of air infiltration constantly varies, depending on a number of factors, while the blower door test is a single measurement. Many building-specific and climate-dependent factors affect actual infiltration. Long-term tracer gas measurements are the only reliable way to obtain average infiltration rates, but tracer gas measurements are impractical for anyone but researchers.

The blower door test provides the equivalent leakage area and also a number for the air changes per hour (ACH) when the house is depressurized to 50 Pascals (0.4" water gauge). Air flow at 50 Pa is high enough to overpower pressure differences caused by wind or stack effects. It is reasonably precise and reproducible. This number is the ACH that R-2000 builders look at, because the R-2000 standard sets a maximum air leakage limit of 1.5 ACH.

The air flow at 50 Pa is not the number we are interested in if we are trying to understand what the air flows are under natural driving pressures. The average pressure across a leak in a building envelope is much closer to 1 or 2 Pa than to 50 Pa. We are interested in the average air infiltration rates because that tells us not only how tight the house is but more importantly how much ventilation and make-up air may be needed. The concern is providing adequate fresh air for occupants.

Actual air change is going to depend on variables other than just the equivalent leakage area, such as house geometry - is it a one storey bungalow, or a 3 storey house?

Wind is an important driving force in infiltration, so it is only reasonable to expect higher infiltration rates in windy areas. The degree to which the house is shielded by vegetation or other buildings will affect the amount of uncontrolled air change.

Stack effect, the effect of the rise of warm buoyant air, induces a pressure difference that causes exfiltration through the ceiling and infiltration at (or below) ground level. Stack effect also depends on the temperature difference between inside and outside. A house located in a cold climate will have more stack-induced infiltration than a similar house in a mild climate. A taller building will also have a larger stack effect. During the summer, stack effects disappear.

Rules of thumb for calculating natural air change vary by climate. A US researcher, John Persily developed a formula to estimate average infiltration rates. His formula is to divide the air change rate at 50 Pascals by 20. This simple formula yields reasonable average infiltration estimates even though it ignores many details of the infiltration process. It does not include any adjustment for wind, trees and shrubs, neighbouring houses or other shielding elements that may protect a house from the wind's full force and which can significantly influence total infiltration. For an accurate assessment, this additional information should be applied to the formula in order to get a correlation factor more accurate for the house.

Another way to convert ACH at 50 Pa to "natural" air changes per hour is to multiply the airflow at 50 Pa by 60 minutes per hour and divide the product by the total heated building volume (including the basement) measured in cubic feet.

How tight is too tight?

What difference does house size have? Is there a difference if two elderly people live in a house or if a family of eight live there?

For building durability and performance it does not matter how many people live in the house but the building envelope must be well detailed and built airtight.

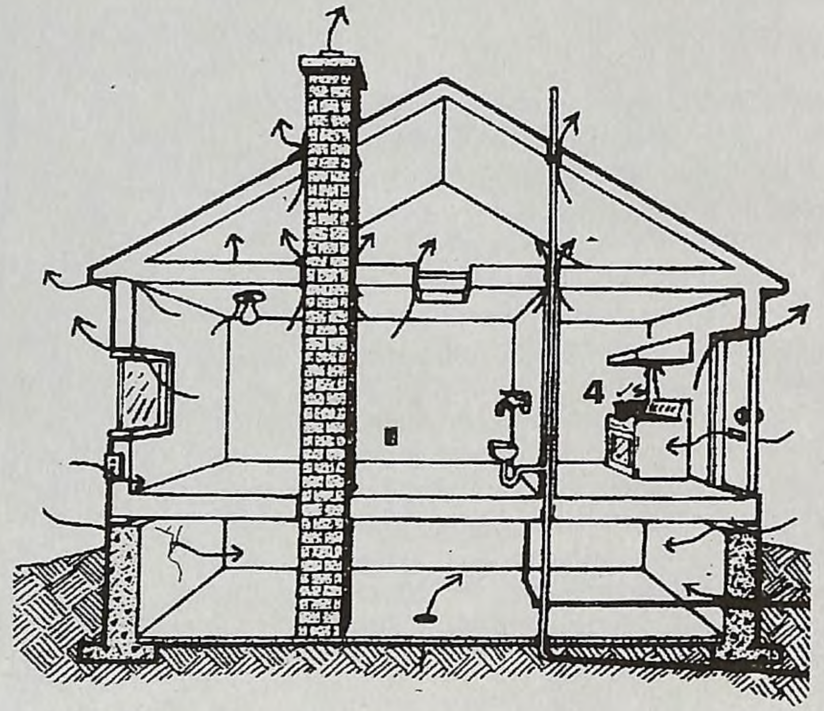
The occupant load and lifestyle is important to ensure that the mechanical systems are properly designed. Ventilation must accommodate the occupant load – which is not dependent on the size of the house.

A well built house should have an adequate designed ventilation for the occupants, regardless how air tight the house or how big it is.

Airtightness is the property of building envelopes most important to understanding ventilation. Air tightness is important because it impacts building energy use, and the transport of contaminants between indoor air and outdoor air.

Infiltration is the movement of air through leaks, cracks or other openings in the building envelope into the building.

Exfiltration is the movement of air through the building envelope outward.



Key Air Leakage Pathways

Construction type may determine what kinds of leakage problems will occur. Leakage can happen anywhere there is a poor connection between two or more materials, and will also depend on the pressure differential across the envelope. Common locations include:

- window and door frame details
- poorly detailed windows
- sliding windows and doors
- penetration of flues and vents through the envelope
- fireplaces on exterior walls
- heating or ventilation ducts that run outside the building envelope
- wall between garage and house
- attic hatches
- foundation to framing connection
- cantilevered framing (bays)
- basement walls and floors
- poorly sealed crawl spaces
- electrical outlets
- ceiling pot lights
- wiring penetrations into attic at interior walls
- floors over unheated spaces
- walls at split levels.

Air leakage can be detected by walking through the house when the house is depressurized with a smoke pencil. The smoke trail at leakage points is readily visible.

ACQ Treated Wood

ACQ treated wood is much more corrosive than CCA, which has been the most commonly used treatment for wood. Because of its corrosiveness, it has led to a search for the correct fasteners to use. Although some literature still makes reference to heavy galvanized (G185) coatings as being suitable, stainless steel connectors are the most effective for ACQ treated wood.

Stainless steel connectors are now becoming more widely available as manufacturers scramble to match the newly developed demand.

However, there does not seem to be much discussion about the need for the use of treated wood in the first place. Use of treated wood is advisable for locations where the wood will remain wet for prolonged periods. A careful review of construction details should be made to determine if wood is the best material for those locations.

Wood will not deteriorate immediately it gets wet as long as it can dry out quickly. Wet wood at warm temperatures (20-30°C) is ideal for fungal deterioration. If wood can dry out quickly after being wet, it will reduce fungal activity and should remain serviceable for a long time. Conventional finishes can be used to protect the wood and maintain the appearance of the wood.

We often forget that the availability and widespread use of treated wood is very recent. It is only in the last 30 to 40 years that it has become a common practice. Although the wood treatment industry may not be keen about it, perhaps it is time to reconsider where we are using wood. We should consider if wood is the best material to use if it must be treated. After all, all those old wood buildings still standing were built without any treated wood, but in most cases with careful attention to water management details. ☼

Energy Star Equipment Ratings

The Energy Star® symbol is an internationally recognized way for consumers to identify products that are among the most energy-efficient on the market. Only manufacturers and retailers whose products meet the Energy Star criteria can label their products with the symbol.

Energy Star was developed by the US Department of Energy as a marketing tool to help identify energy efficient products. In Canada, Energy Star is supported by NRCan, which has modified the criteria that products must meet in order to qualify for Canadian Energy Star recognition.

To be able to display the Energy Star symbol, products must meet or exceed technical specifications designed to ensure that they are among the most energy efficient in the marketplace. Requirements vary from product to product, but typically an Energy Star model must be10 to 50 percent more efficient than a conventional model.

The impact of an Energy Star-labelled product over a conventional model could save consumers hundreds of dollars in operating energy costs. The use of energy-efficient products also has environmental implications, because in many parts of Canada fossil fuels are used to produce electricity. The burning of fossil fuels is a major source of greenhouse gas (GHG) emissions - a leading cause of climate change - and other pollutants that contribute to urban smog and acid rain. When less energy is used by the use of energy-efficient products, less electricity needs to be produced, thus reducing GHG emissions and promoting cleaner air as well.

Energy efficient fossil fuel fired home heating equipment such as furnaces or water heaters will also produce less GHG emissions and other pollutants when they are more energy efficient, making for a cleaner, greener community.

Forced Warm Air Furnaces

Residential gas or oil furnaces must have an annual fuel utilization efficiency (AFUE) of **90% or more**. High-efficiency furnaces with a variable-speed DC motor to run the air circulation fan, which can significantly reduce electricity consumption while providing better heat distribution.

Boilers

Residential boilers must have an AFUE rating of **85% or higher**.

Ventilation Fans

Energy Star qualified fans use, on average, 65 % less energy than standard models. Because of better blade design, they move more air with less noise and their high performance motors last longer. Qualifying fans include range hoods, bathroom fans, utility fans and in-line fans. If the fan contains a light fixture, the total lamp wattage must not exceed 50 Watts. The use of compact fluorescent lights (CFLs) is recommended. Fans with a "night-light" must have a lamp that consumes 4 watts or less.

Other products that are listed include ceiling fans and programmable thermostats.

Product	Airflow	Minimum Efficacy Level	Maximum Sones*
Range Hoods	Up to 500 cfm (14.2 m³/min)	2.8 cfm/watt (0.08 m³/min)	2.0
Bathroom and Utility Room Fans	10 to 80 cfm (.3 to 2.3 m³/min)	1.4 cfm/watt (0.04 m³/min)	2.0
Bathroom and Utility Room Fans	90 to 130 cfm (2.5 to 3.7 m³/min)	2.8 cfm/watt (0.08 m³/min)	2.0
Bathroom and Utility Room Fans	140 to 500 cfm (4.0 to 14.2 m³/min)	2.8 cfm/watt (0.08 m³/min)	3.0
In-line Ventilating Fans	Any	2.8 cfm/watt (0.08 m³/min)	Not applicable

** a sone is a measure of how loud the fan is when in operation. The lower the number, the quieter the operation. Although not an Energy Star requirement, bathroom fans especially should be as quiet as possible - the most effective and quietest fans have a rating of 1 sone or less. A 2 sone fan will still sound noisy and irritate many people.*

Air Source Heat Pumps

The energy efficiency of air source heat pumps is measured by a Heating Seasonal Performance Factor (HSPF), a Seasonal Energy Efficiency Ratio (SEER) and an Energy Efficiency Ratio (EER). Energy Star qualified air-source heat pumps are about 20% more efficient than standard models.

R-2000

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000 www.R-2000.ca

Air Source Heat Pumps			
	HSPF	SEER	EER
Split air source heat pump	8.0	13.0	11.0
Single Package	7.6	12.0	10.5

Ground-Source (Geo-thermal) Heat Pumps

Ground-source heat pumps use the thermal energy in the ground or groundwater as a source of heating and/or cooling for a home. There are three basic types: 1) closed loop; 2) open loop; and 3) direct expansion. The cooling function is measured by an Energy Efficiency Ratio (EER), and the heating function is measured by a Coefficient of Performance (COP). The higher the EER or COP number, the more efficient the heat pump is. Energy Star qualified ground-source heat pumps must meet or exceed the following EER and COP levels:

Canadian Energy Star qualified products are listed on the NRCan web site: *www.energystar.gc.ca*

Geothermal Heat Pumps		
Product Type	EER	COP
Closed Loop	14.1	3.3
Open Loop	16.2	3.6

Central Air Conditioners

Energy Star qualified central air conditioning systems are about 20% more efficient than standard models. The energy efficiency is measured by a Seasonal Energy Efficiency Ratio (SEER) and an Energy Efficiency Ratio (EER). To qualify for Energy Star, units must meet or exceed:

Single package units with electric air-conditioning and gas heating cannot qualify for Energy Star in Canada.

Central Air Conditioners		
	SEER	EER
Split systems	13.0	11.0
Single Package	12.0	10.5

New Green Products

The editors of **GreenSpec®** and **Environmental Building News™** publish and annual list of new "green" products. The 2005 Top-10 Product list has just been released. Several of the products will be of interest to homebuilders.

LED Lighting

Light-emitting diodes (LEDs) are the only non-incandescent light source that does not rely on mercury vapor. Efficacy has increased dramatically in recent years to over 50 lumens per watt for today's best white LEDs. They also have a very long life - from 30,000 to 50,000 hours. The Enbryten™ luminares by Permlight Products use high-efficacy, white LEDs. These are available in a range of pendant, downlight, and sconce luminaires that can be used in homes and commercial buildings.

A LED downlight luminaire can effectively replace a 60-75 watt incandescent luminaire, yet consumes just 15-18 watts. In addition, the ability to focus light from LED luminaires can allow such a luminaire to replace an incandescent luminaire with a much higher total light output.

Permlight Products, Inc.
Tustin, CA
www.permlight.com

More information on new Green building materials can be found in the GreenSpec directory. *www.BuildingGreen.com*

Dual Flush Toilet

Dual-flush toilets, long popular in Australia, Western Europe and East Asia, offer two flush options: a standard 6 litre flush for solid wastes and a lower-volume flush for liquid wastes and paper. Now Toto has introduced its Aquia™ dual-flush toilet to the North American market.

Formaldehyde-Free Hardwood Plywood

Columbia Forest Products, the largest North American manufacturer of hardwood plywood, announced a transition to soy-based binders for all of its veneer-core and veneered Agrifiber-core panel products. Branded under the name PureBond™, the panels use a soy-based binder in place of the industry-standard urea-formaldehyde, which results in significant emissions of formaldehyde. The new binder, developed by scientists at Oregon State University, is 87% soy protein, with the remainder a proprietary petrochemical-based polyamide resin. It is a water-based, non-flammable, nontoxic binder. The switch to this binder has had no effect on product pricing and all Columbia Forest Products manufacturing facilities are expected to complete this conversion during 2006.

Columbia Forest Products
www.columbiaforestproducts.com

Depressurization Spillage Test for Gas Fired Appliances

Historically, combustion appliances used in houses have relied on chimneys to remove their products of combustion from the living space. This type of venting relies on the buoyancy of the warm flue gases to remove them from the home, and is also referred to as "natural draft". To avoid excessive draft when the flue gases are hot and to partially decouple the appliance from the chimney, a draft hood is installed either at the appliance or in the vent between the appliance and the chimney. The draft hood allows cooler air from the house to be drawn into the combustion venting system when needed to reduce the temperature of the combustion gases by dilution, reducing the negative pressure (or draft) at the appliance when the burner has been operating for an extended period.

Because of the historic differences between gas-fired and oil-fired appliances, the design and operation of their draft control devices was different. For naturally aspirated gas-fired appliances the combustion venting system is intended to operate with a negative pressure in the vent between the appliance and the chimney or stack. For oil-fired appliances, which have used power burners for many years, the dilution device is called a "barometric damper". It is not an integral part of the appliance, but is installed in the vent section. It is designed to close during start-up to prevent spillage when the pressure in the vent between the appliance and the stack may be positive until sufficient chimney draft develops.

Draft hoods allow air to flow in either direction. As a result they generally allow for some spillage on start-up. Barometric dampers are normally designed to allow flow in only one direction to avoid start-up spillage with the power burners

Residential combustion appliances worked reasonably well when they were properly installed and connected to correctly sized chimneys in relatively leaky (with respect to air tightness) houses. Leaky houses could normally provide enough air for combustion and dilution. However, even when installed in leaky houses, there have been issues associated with poor venting and combustion spillage during some weather conditions, or when other exhaust equipment was operating.

Today's houses are much tighter than older homes. Exhaust appliances used today, such as clothes dryers, range hoods and bathroom fans all can have significantly higher capacities than those used twenty years ago. New high-powered exhaust equipment, such as downdraft cook-tops or barbeque stoves, central vacuums installed in garages and other power vented combustion appliances are also being installed. When these exhaust devices are operated, especially several at the same time, can create high depressurization levels and increase the potential for combustion gas spillage in spillage susceptible appliances as well as reverse flows in chimneys.

That is one reason why the R-2000 Standard has had strict requirements about spillage susceptible appliances and also requires testing to avoid depressurization in excess of 5 or 10 Pascals.

Combustion gas spillage from combustion appliances is a complex problem. The frequency and severity of spillage is influenced by the design size and installation practices of the equipment, its location, the appliance capacity, the airtightness of the building, and the weather conditions. Spillage may also be caused by the use of other exhaust equipment that can overpower the venting system.

Canadian Codes and Standards have tried to deal with combustion spillage by requiring make-up air supplies where there may not be enough air leakage to support the proper operation of the combustion appliances.

Manufacturers generally have designed appliances to be more spillage-resistant. They have either been designed in a way that their combustion and venting components should not be exposed to the pressure regime inside the house, or they have been equipped with strong power venting systems that should be able to operate even when depressurized conditions exist.

However, there are no protocols for testing of products for combustion spillage resistance.

The depressurization spillage test

The combustion appliance is installed inside a sealed test room, in accordance with the manufacturer's instructions, using approved venting materials and maximum vent lengths.

The test room is depressurized before the appliance burner is activated. A fan is used to draw air from the test room so that the appliance can be tested against different levels of depressurization.

The appliance is fired up and measurements are taken of the room pressure: the fuel consumption rate, the airflow from the room by the depressurization fan and the CO_2 concentration in the air being removed from the room and the CO_2 concentration in the surrounding area collected for seven minutes. This ensures that start-up and shut-down combustion spillage will be include in the test. The temperature in the test room is allowed to "float" during the test.

That is why NRCan and CMHC have supported the development of a pressurization spillage test. The intent is to have a simple test procedure that could be used with any type of combustion appliance. The spillage test that has been developed will allow manufacturers to include depressurization spillage resistance ratings in their literature alongside the other performance data. In the longer term, combustion spillage tests may be included within the applicable appliance safety standards to enable manufacturers to differentiate their products.

The test developed is a relatively simple depressurization spillage test that can be used to differentiate between products that spill and those that do not. It requires the appliance burner to be fired for five minutes and data to be collected for seven minutes. This ensures that start-up and shut-down combustion spillage will be include in the test. The temperature in the test room is allowed to "float" during the test.

The facility and instrumentation requirements for the depressurization spillage test are simple enough so that a manufacturer should have little or no difficulty in setting up the test in their own facility and also using it as a product development tool. This will help them verify the performance of their products and improve their spillage resistance without resorting to expensive third party laboratory tests. Many existing products are capable of performing very well. Some will not. This test will differentiate the good from the bad.

To test the procedures, tests were done on seven appliances: two water heaters, three furnaces and two gas-fireplaces. The appliances were off-the-shelf items purchased from regular distributors chosen to represent a cross-section of gas-fired equipment commonly installed in Canadian homes.

When tested at 50 Pa depressurization, three products had essentially undetectable levels of combustible spillage, three had low but measurable combustion spillage (between 0.75 and 1.5%) and one had significant combustion spillage (approximately 13%). Spillage of 2% was considered the maximum allowable. ☼

Development and Evaluation of a new Depressurization Spillage Test for Residential Gas-Fired Combustion Appliances *prepared for Natural Resources Canada and Canada Mortgage and Housing Corporation by Peter Edwards.*

Minnesota Energy Code: Combustion Appliance Requirements

The 2000 Minnesota energy code has requirements for protection against excessive depressurization. The least restrictive path requires that all vented combustion appliances be "sealed combustion." Minnesota defines "sealed combustion appliance" as an appliance that acquires all combustion air through a dedicated sealed passage from the outside, to a sealed combustion chamber, and all combustion products are vented to the outside through a separate dedicated sealed vent. The appliance must be able to function and draft properly at a negative pressure of 50 Pascals.

The state web site also cautions that not all direct vent furnaces and water heaters may meet the definition of sealed combustion.

When the code was adopted, it was recognized that there was no standard for sealed combustion appliances, so the state allowed manufacturers to self certify that their equipment meets the requirements of this definition when installed according to the manufacturer's instructions.

Most major furnace manufacturers have filed letters with the state of Minnesota stating which of their products meet the requirements. These letters are available on the state's web site. Manufacturers are specific about which models comply. Some have provided detailed information, others only a cursory note that a specific product complies.

For information: www.commerce.state.mn.us look for the buildings & builders section of the Consumer Info and Services section.

Technical Research Committee News

Green Strategies for Plumbing Systems

The growing interest in more environmentally responsible development is challenging the traditional ways we build and service buildings. Water and sewage systems have been recognized as the area where changes need to be made. Our per capita water consumption exceeds that of everyone else in the world. In spite of the seeming endless amounts of fresh water in Canada, we are learning painfully that the infrastructure can't keep up with demand, and that the resource itself is finite. Yet water is a precious commodity that is fundamental to all life on earth, not a luxury.

However, it seems that our regulatory systems may be behind than the rest of the world. To deal with water and water management issues, we need to rethink not just how much, but also how we use and manage water and sewage systems. Our traditional approaches are largely crude. There is a lack of clarity in our standards for dealing with water and sewage use. Those who want to take advantage of innovative approaches too often face regulatory obstacles in the absence of clearly identified objectives and standards. That is why CSA has several initiatives underway.

Dual plumbing systems (Non-potable Water Systems)

A new CSA Technical Committee is developing a first-generation standard for dual plumbing systems. These will enable the reuse of grey water and deal with harvesting of rainwater. The new standards expected to be published in the spring of 2006.

Onsite Sewage Treatment Systems

In some locations conventional site servicing is not feasible, so homeowners must install their own sewage treatment on site. The system most are familiar with is the septic tank, but these are not the only type of on-site sewage treatment system. In some areas a septic tank is simply not possible. Currently there is a patchwork of requirements for on-site sewage treatment. General support has been confirmed for a national consensus standard for the Installation of On-site Sewage Systems.

CSA will be reviewing current requirements in the provinces and territories to provide a baseline summarizing the similarities and differences, after which work will commence to develop draft national requirements.

Factory Built Housing Standards

The CSA Factory Built Housing Standards apply to a significant portion of new housing that is built off-site.

The CSA Z240 MH series, which includes definitions and general requirements, vehicular structural and plumbing requirements, installation requirements for gas and oil burning appliances, and HVAC load and design requirements.

Because of the unique circumstances, as manufactured homes are built off site as a module, the foundation preparation and anchorage is important, and that is covered by CSA Z240.10.1, site preparation, foundation, and anchorage of mobile homes.

Since these manufactured homes are built beyond the jurisdiction of local building inspectors, there is a need to define the administrative procedures. These are covered by CSA A277 - Procedure for certification of factory built houses.

The CSA standards generally mirror the requirements of the National Building Code. With the publication of the new building code, the CSA manufactured housing standards have to be revised to take into account changes made to the 2005 edition of the National Building Code. Some of the changes under review will include adjustments in snow loads, ceiling heights, hallway widths, doors, windows, stairs and vapour barriers. The new editions of the CSA standards are expected to be published in the summer of 2007.

Furnace Energy Efficiency Rating

The technical subcommittee responsible for the CSA Standard for residential furnace efficiency (P2) is currently debating the addition of a measurement of electrical energy in the efficiency standard. Currently, the common practice is to report only the Annual Fuel Utilization Efficiency (AFUE) which determines the efficiency

Canadian Home Builders' Association

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.

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with which gas is converted to useful energy.

However, today furnace blowers are often run continuously as they are used to circulate ventilation air and to provide air filtration. The inefficient blower motors on many furnaces can consume significant amounts of electrical energy. The heat given off by the blowers can actually contribute to overheating in energy efficient houses. That is why NRCan is proposing that new test requirements which would separately measure furnace blower and other electrical energy consumption. The NRCan proposal would also require measurement of electrical consumption under various operating conditions, such as in continuous ventilation mode and high and low speed heating modes. The NRCan proposal would result in four or more electrical consumption numbers for each furnace.

Manufacturers are proposing that the CSA standard use the existing single measurement currently in place in the US. That standard identifies electrically efficient furnaces as those whose electrical energy consumption represents less than 2% of the total energy used by the furnace in a "typical heating season" and are listed with an "e" in the Gas Appliance Manufacturer's Association (GAMA) directory. The GAMA proposal would result in one number for annual electrical consumption, plus an "e" symbol if the furnace is electrically efficient.

The debate continues, but it is expected that there will be a proposed method for measuring electrical energy consumption for the next version of the furnace efficiency standard, which is scheduled for publication in 2007.

Venting Systems for Gas and Propane Appliances

Proper installation of vents, especially for direct vent gas appliances that are side wall vented is important to ensure proper venting and safe operation of the equipment. In order to deal with concerns and lack of understanding of code and standards applicable to this equipment (CSA-B149.1 Natural Gas and Propane Installation Code), the Alberta Safety Services and the Gas Technical Council drafted a bulletin to ensure that Designers and Installers are aware of code provisions to ensure the proper termination of vents.

Maintaining minimum clearances will reduce the probability that moisture and contaminants from flue gases will create a hazardous condition.

☛ The vents must not terminate above common paved sidewalks and driveways between two single-family dwellings, since the condensate from the flue gases could freeze on the paved surface or damage adjacent parked vehicles.

☛ The 7 ft (2.1 m) minimum termination height of vents above public paved sidewalks and driveways is intended to avoid icy surfaces and other hazards for pedestrians.

☛ The vents must not terminate within 6 ft (1.8 m) of a mechanical air supply inlet to reduce the probability that the flue gases will contaminate incoming air supply.

☛ Distance from the gas meter/regulator sets is intended to reduce the probability of a malfunction when condensation from the flue gases freezes on a regulator and blocks vent opening.

☛ Vents must terminate at least 1 ft (300 mm) above grade to minimize the risk of becoming blocked with snow and accumulation of debris.

☛ Clearances to non-mechanical air inlets are based on the input of the appliance, since this determines the amount of flue gas discharge.

☛ Termination of vents underneath a veranda, porch or deck must be open to provide free air circulation to adequately dilute the flue gases and reduce the probability of a contaminated air supply and damage from condensation.

Alberta Municipal Affairs – Safety Services STANDATA GAS SAFETY Information Bulletin G-04-02-B149.1

Dry And Comfortable Floors In Existing Basements

Increasingly homeowners finish their basements to create more living space. However, creating a living space in a damp environment can lead to building material degradation and health problems.

Most existing basements have a problem because they are underground and susceptible to water leakage. Most were built without the thought they would be finished living space. CMHC studies show that in many parts of Canada up to half the basements have signs of moisture damage as a result of high humidity or water leaks.

Another challenge is that because basement floors were not intended to be finished spaces, they are not smooth and level. They can be rough and uneven concrete and usually are not insulated.

Although there has been some research on basement walls details to resist moisture, little work has been done about what flooring works well on concrete slabs. There is very little data on flooring options and their performance in wet environments. For instance, there is little research comparing the performance of hardwood floors to laminate floors following a short flooding event, or the moisture conditions under a polyethylene sheet beneath a carpet.

Dry basements, especially those with the slabs that are insulated underneath, can be finished in almost any manner without risk. Basement floors that suffer wetting, either from summer condensation, moisture movement through the concrete or occasional leakage, are harder to finish. Water will damage surfaces and promote the growth of mould.

The least-expensive, safest floor finishes for wet basements are bare or painted concrete. There are alternatives that can be used judiciously, but the possibility for moisture may have moderately better resistance.

A CMHC research project looked at the options for finishing basement floors and their suitability for possible moisture problems. Researchers surveyed literature about options for finishing basement floor slabs in existing houses. Because many basements have significant, preexisting moisture problems, the project looked at two specific conditions:

1. No observable basement water-leakage problems, but the possibility of condensation in spring and summer.

2. The possibility of incidental water leakage, sporadic water leakage or moisture movement - (or all three) through the floor slab.

If the basement floor is dry, and is not wetted a result of wall or floor leakage, or capillary action then it is assumed that any flooring option is permissible.

Flooring options

Cleanable and disposable coverings include conventional scatter rugs and sheet flooring not intended for permanent installation. These can be used if the homeowner recognizes that they may have to be periodically removed and cleaned or discarded if there is a major wetting event.

Conventional area coverings such as carpets and sheet flooring intended for permanent installation in the basement. These cannot be easily removed for cleaning and are best used in areas where there is a high degree of confidence that the basement will remain dry.

Built-up, non-insulated floor systems.

Often the existing floor slab cannot be used as the base for a finished floor system because of serious moisture problems or because the floor is cracked, uneven or in generally poor condition. In these cases a new, built-up floor system can be built on top of the original slab to provide a level, dry working surface on which the finished floor is applied. A typical built-up floor system could be:

- a finished floor (any type can be used);
- a subfloor, typically plywood or OCB;
- furring or wooden sleepers, which either support or level the subfloor; and
- a polyethylene sheet, which functions as a moisture and vapour barrier:

Built-up, insulated floor systems

Similar to built-up, not-insulated floor systems, but with a layer of insulation added as part

of the floor system to reduce heat the loss and raise the floor's surface temperature, resulting in improved comfort and condensation resistance. The insulation should be moisture resistant.

Drainage mats and new subfloor

This built-up floor uses a drainage mat (sometimes called an "air-gap membrane") underneath a new subfloor. There are two alternatives: pre-manufactured panels, commercially available in nominal (2 ft. x 2 ft.) sizes, and site-constructed drainage floors created from rolls of drainage mat.

Three types of basement moisture problems were identified.

1. Minor moisture problems. This is the mildest form of basement floor wetting. It is the condition when there is no obvious visible water-leakage problems. Spring and summer condensation may exist on the floor or on other locations in the basement when the indoor relative humidity is high and portions of the basement floor (or other parts of basement) are below the dew point. These types moisture problems are the least destructive type of basement floor wetting.

2. Moderate moisture problems. Wetting happens mainly due to capillary action through the floor slab, although there may also be some condensation of indoor air. If a floor exposed to moderate moisture threats can be sealed, then the same list of floor options shown for minor moisture problems can be used.

3. Major moisture problems. Moisture movement takes place by bulk water leakage and also by capillary action through the slab. There may also be condensation the result of high water table, either seasonal or year round, or by construction defects. If the floor is exposed to major threats and if the water table can be lowered and there is a good confidence that moisture sources have been dealt with, then the same list of floor options shown for minor moisture problems can be used.

Options For Moderate Moisture Problems

First seal the basement floor and re-test for capillary movement with the Polyethylene Patch Test. If the sealing works, then use:

- Paints and coatings
- Cleanable and disposable coverings
- Conventional area coverings
- Built-up floor system; non-insulated
- Built-up floor systems; insulated
- Drainage mats and new subfloor

If the sealing does not work, then use:

- Paints and coatings
- Built-up floor systems; non-insulated
- Built-up floor systems; insulated
- Drainage mats and new subfloor

Options For Floors With Major Problems

First lower the water table to a level that is below the level of existing floor surface and Retest for bulk water movement using the Standing Water Test.

If the floor passes the Standing Water Test:

- Paints and coatings
- Cleanable and disposable coverings
- Conventional area coverings
- Built-up floor system; non-insulated
- Built-up floor systems; insulated
- Drainage mats and new subfloor

If floor does not pass the Standing Water Test:

- Paints and coatings
- Built-up floor systems; non-insulated
- Built-up floor systems; insulated
- Drainage mats and new subfloor

Dry And Comfortable Floors In Existing Basements by Gary Proskiw, Proskiw Engineering Ltd. For CMHC

Testing For Water in Basement Floors

It is critical to know as much as possible about the history of the house, especially if the investigation is done near the end of the dry season or after a drought.

A basement floor may appear to be dry even if moisture is moving upwards through the slab, because the moisture is able to evaporate into the interior air space as fast as it is transported through the slab. When an impermeable membrane is installed over a slab (such as the polyethylene patch test), water is able to accumulate on the surface of the slab, under the polyethylene.

Polyethylene Patch Test

This is an easy test to test determine if moisture is moving through an existing floor slab by capillary action.

Place pieces of clear polyethylene (each about 2 ft. x 2 ft.) on top of the slab. Seal the perimeter of the polyethylene to the floor, using duct or masking tape. Leave the patches in place for two or three days.

Ideally, two to five patches should be used, each on a different section of the floor slab. Portions of the slab that are not being considered for the new floor system can be ignored. To complement the polyethylene patch test, the slab can be examined for efflorescence. Since efflorescence only develops when a significant amount of liquid water has been transported through the slab due to capillary action, the presence of efflorescence can be treated as in indication that there is capillary movement.

If there are no damp spots visible on the underside (floor side) of the polyethylene after a few days, then it can be assumed that moisture is not moving through the slab by the capillary action - at least during the test period. If there is condensation on the top (house-side) of the polyethylene, the moisture is originating from internal (house) sources.

Standing Water Test

This test determines whether moisture is moving through the slab due water leakage. Look for areas of the floor slabs that have wet areas.

Slab wetting can happen by capillary action, water leakage from below or water drainage from above by leakage through the basement walls, which can result in water accumulating on the slab. Capillary action is not capable of moving enough quantities of water to the surface of the slab for standing water. Thus, the presence of standing water or a visibly wet patch of concrete indicates the slab is saturated and that an additional moisture transport mechanism is at work (such as water leakage from below or above).

Standing water as a result of leakage through the basement walls (which ultimately ponds on the floor) should not be interpreted as a test failure, since the source of water is not through the slab. Wall leaks should be repaired at the earliest opportunity, not just to protect the new, finished floor surface but also to protect the interior, insulated portion of the basement wall. This is especially important for controlling mould growth, since airborne mould spores are able to move from the insulated basement wall into the occupied portion of the basement and house.

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Energy Answers

Rob Dumont

What is the Factor 9 Home Project?

The Factor 9 Home is a new residence to be built in Regina, Saskatchewan in 2006 that will use 90% less purchased energy than a conventional 1970 home. In addition, the home will use 50% less purchased water than a conventional home.

Where does the term Factor 9 come from?

The Factor 9 comes from a projected 9 fold decrease in purchased energy consumption compared with a conventional average home in Regina.

Why are you going to this level of performance?

As anyone who has read the book ***Collapse*** by Jared Diamond will know, the earth has an unfortunately large number of communities that collapsed in the past mostly by overusing their natural resources. Easter Island in Polynesia, the Norse Community of Greenland, and the Mayan Civilization of Mexico are but a few of the civilizations that have collapsed. If current trends continue, most of the world will end up in a similar state of collapse.

To cite one example, world oil consumption has increased by a Factor of 10 since the end of WWII. This enormous growth rate is not sustainable in a finite world. Even very modest growth rates over time can have very large consequences. Here's an example: Take one penny in the year A.D. 0 and invest it at the modest compound interest rate of 2% per year. By the year 1900, that penny is worth 2.2 x 10^{14} dollars or 220 Trillion dollars, more wealth than the current Gross National Product of all nations in the entire world! A finite world cannot sustain exponential growth in resource consumption very long. Even a rate of 2% growth, or, for that matter, 0.2% growth over a long enough period of time, results in unacceptably high consequences.

The Factor of 9 comes from the following:

World population is expected to grow by a factor of 1.5 before it stabilizes. The consumption level per average person in the world is expected to grow by a factor of 3 before stabilizing, and the climate scientists are telling us that we must reduce our current greenhouse gas production by a factor of 2. Multiply these three factors and the number 9 results.

Factor 9 thinking is needed for all of our energy using devices–buildings, industrial processes, transport vehicles, etc.

What will the Factor 9 Home look like?

The design is not yet finalized, but the house will be a bungalow. On the space heating side, the house will feature a very well insulated and sealed envelope, coupled with strong use of passive and active solar heating technologies. The budget does not allow for a photovoltaic system, but a south facing roof slope is being used that can later accommodate PV panels as the cost of these devices fall. (We even plan to put a conduit in place to allow for a simple future addition of the PV panels.)

Appliances will be Energy Star or better, and most of the lighting will be compact fluorescent.

A rendering of the north side of the house is shown in Figure 1. We anticipate that construction will start in March of 2006.

For more information on the project, have a look at *www.factor9.ca*

Acknowledgments: The Factor 9 Home Project is indebted to many sponsors including the following: The Communities of Tomorrow (www.ctinfo.ca), the Office of Energy Conservation of the Government of Saskatchewan, the Saskatchewan Research Council, Natural Resources Canada, Canada Mortgage and Housing Corporation, Panbrick Incorporated, Emercor Ltd., and the future owners of the Home, Rolf and Shannon Holzkaemper. Partners in the project include the City of Regina and the University of Regina. Additional sponsors are being sought.

Figure 1. North view of Factor 9 Home: A New Prairie Approach

NRC·CNRC

Using Garden Roof Systems to Improve Performance

by K.Y. Liu

In an age marked by increasing emphasis on sustainability, durability and energy efficiency, garden roofs are gaining in popularity in North America. These specialized roof systems provide a touch of greenery in our urban environments and at the same time achieve better thermal performance than traditional roofs. They also retard and reduce water run-off, contributing to storm water management in the urban area.

Also known as green roofs and rooftop gardens, these systems can be installed on both conventional and protected-membrane roofs (Figures 1 and 2). They require additional components including a root-resistant layer, a drainage layer, a filter membrane and a growing medium for the vegetation.

Garden roofs can be categorized as "intensive" or "extensive," based on the system weight. Intensive systems utilize deep growing mediums capable of supporting a wide variety of small trees and shrubs. They require a high level of maintenance and because of the types of plants they support. Intensive garden roofs normally must be incorporated into the original building design due to the structural load requirement.

Extensive garden roof systems have shallow, lightweight growing mediums, which can support only small plants such as herbs, grasses and wild flowers. They are intended to be low maintenance, and therefore require plants that are hardy, draught tolerant and preferably self-generating. Because the structural loading is lower, many existing buildings can be retrofitted to accommodate extensive systems.

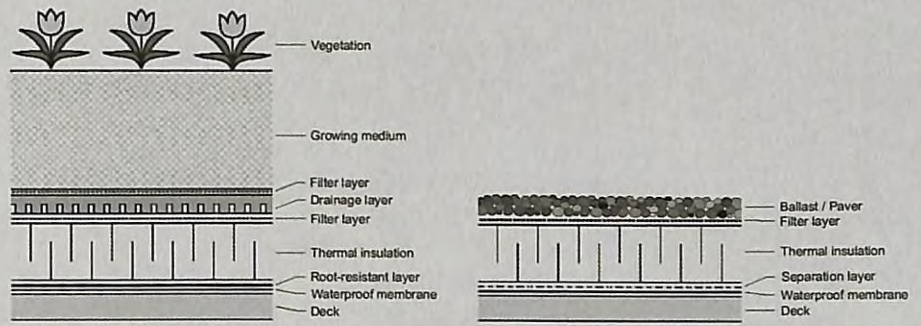

Figure 2. Protected membrane roofing system with and without a garden roof system.

NRC researchers have been assessing the performance of a garden roof they constructed as part of a low-slope industrial roof test facility in Ottawa. The roof is divided into two equal sections. One section was a garden roof with grass growing in 150 mm of lightweight growing medium and the other section, the reference roof, was a conventional modified bituminous roof.

Some results from the NRC project are highlighted as follows.

◆ **Roof membrane protection:** It is common knowledge that exposure to *heat and ultraviolet radiation reduces the service life of a roof membrane. It appears the opposite can be achieved with garden roofs. During the NRC testing,* the membrane on the reference roof experienced significantly higher temperatures than the one on the garden roof, especially in the warmer months. On a typical summer afternoon (outdoor temperature above 30°C), the exposed conventional membrane reached 60°C while the garden roof membrane reached only about 25°C. In the winter, the temperature profiles for the two roofs were similar because of the insulating effects of the snow coverage.

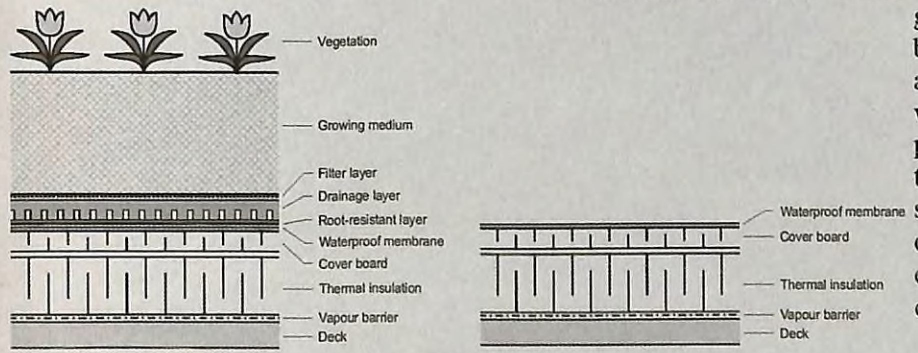

Figure 1. Conventional roofing system with and without a garden roof system.

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◆ **Heat flow and energy efficiency:** *Heat flow between a building and its environment creates energy demand for space conditioning.* During the NRC testing period, the garden roof reduced heat gain through the roof by 95% and heat loss by 26% in a year. This amounted to an overall reduction in heat flow of 47% compared to the conventional roof (based on the Ottawa test facility location). Although results will vary by region across the country, the Ottawa tests suggest that garden roofs can save energy by reducing the cooling and heating requirements for a building.

◆ **Retention of storm water runoff:** In urban areas, storm water runoff from impervious surfaces such as rooftops and pavements during a heavy rainstorm can overload storm sewer systems, causing flash floods and sometimes combine sewage overflow. The garden roof in Ottawa was shown to be able to delay runoff, and reduce the peak runoff rate and volume. The retention efficiency depended on the type and amount of growing medium, the vegetation, as well as the rain pattern. Over the course of a year, the garden roof in Ottawa reduced the runoff by 54%. It is likely that garden roof systems designed with deeper and more absorbent soil, as well as more vegetation, would retain even more storm water than the system tested by NRC.

While garden roofs provide benefits, there are also some cautions. The initial cost is higher than a regular roof because of the extra components involved. Also, they are not maintenance-free. Building owners need to be aware of this and make a commitment to maintain the roof and garden. Another important point is that these specialized roof systems must be carefully designed. It is recommended that a leak detection test be performed on the membrane both before and after the installation of the growing medium and vegetation to ensure that the roof membrane is watertight.

Although garden roofs are most often installed on flat industrial roofs, they can also be installed on sloped residential roofs. The key is to plan for this innovation in advance due to the extra loading capacity required. ☼

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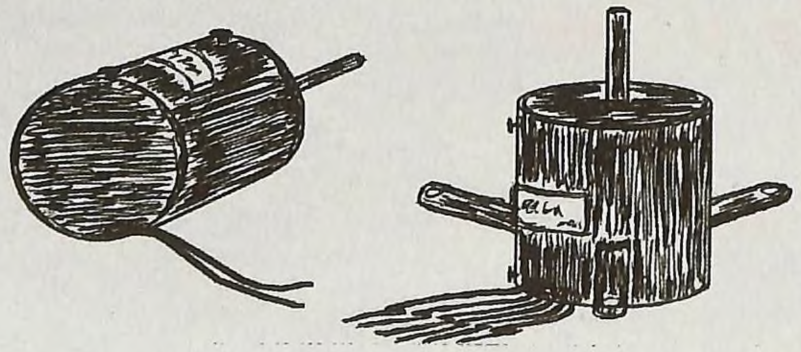

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You Asked Us: About Foil Faced Insulation

I am a carpentry instructor at the local community college. Recently I have had many people ask about P2000 insulation, a "new" foil faced expanded polystyrene (EPS) insulation product for which the product manufacturers make high R-value claims. I am looking for some opinions about this product.

I have read reviews about this and other radiant barrier products and I am skeptical of their claims. Even Thermax, which is a foil-faced foam board, only claims an R 6.6/inch thickness and it is made of polyisocyanurate, not EPS. Do you have any comments?

The P2000 insulation product you mention is an expanded polystyrene board, available in ¼ to 2 inch thicknesses, to which aluminum foil has been laminated to provide a reflective surface. It is not listed in the CCMC product directory.

Foil faced materials have long been touted as a miracle insulation. Outlandish claims have been made for the reflective insulation products. Radiant barrier manufacturers test their products under unique test protocols, different from that of other products, and then compare their products against the others. The challenge is to understand the appropriate conditions under which reflective products provide benefits and to understand where it is appropriate to use them.

R-values have been criticized by some for being unrealistic. However, the test procedures used to calculate insulation properties are well understood and offer a fair basis of comparison. Despite any failings the test procedures may have, they have stood the test of time and provide a fair basis for comparison of different products. It is not unlike the performance tests for automobiles – no one drives a car the way the tests are done, but they do offer comparative performance values.

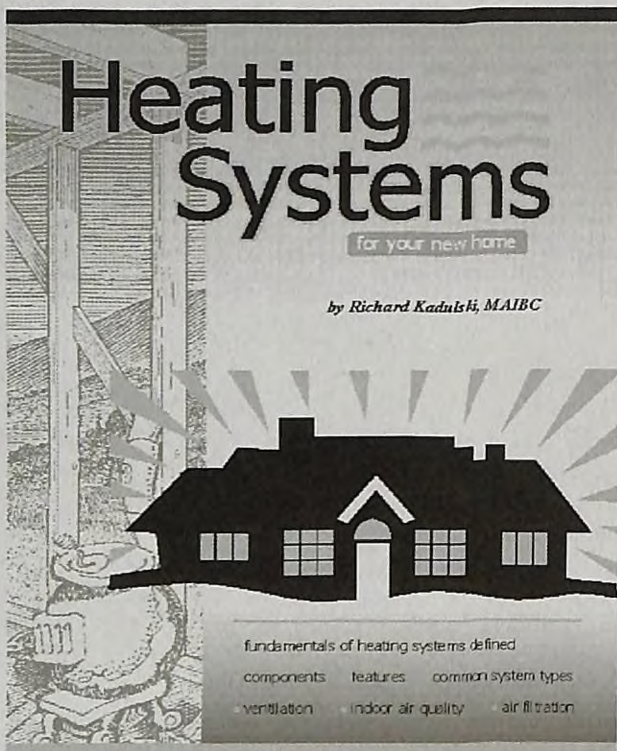
The manufacturers of this product claim that their one-inch thick board offers a better insulation value than R-40 batt insulation. It is the EPS board that provides much of the insulating value, although the EPS itself only has an R-value of 4 per inch or less. The foil face may increase the thermal performance, depending on its location and the environmental conditions. The manufacturers' product literature does offer information from materials test labs to backup their claims, but the test report itself indicates that a unique testing protocol was used, so it must be looked at with caution.

The manufacturer does stress the importance of sealing (with a tape) all joints in the insulation making the building more airtight, reducing air leakage. By placing the insulating board over the framing it will also significantly improve the building performance by reducing thermal bridging through the framing elements and improve the effective value of the whole assembly. They also stress the importance of a strapped air space in front of the material, which is required in order to gain and benefit from the radiant barrier.

It is also worth noting that the highlighted applications for the products are industrial buildings and ice rinks. These buildings are usually metal frame and often very poorly insulated with batts wrapped in poly. In a poorly insulated building, any improvement will provide significant performance improvements, especially when it reduces the thermal bridging and air leakage of the building. When looking at performance improvement claims in such buildings does require some discretion.

Radiant heat flows are not significant in most Canadian building envelope applications at normal operating conditions. A radiant barrier in an attic will reduce heat gain and thus cooling loads in the summer. Radiant insulation on high temperature elements, such as boilers and hot water lines, will reduce heat loss. But those are extreme cases, and do not compare with the conditions normally encountered in a building envelope.

The foil-faced insulation does improve the effective insulation value by reducing thermal bridging, and it does provide a vapour barrier. However, a one or two inch thick board simply cannot be considered as a substitute to R20 or R40 insulation, of whatever kind. ☼



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